TECHNOLETTERS

Quarterly Published By

Department of Electronics & Communication Engineering

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Volume 3 – Issue 2 – 2025 (Apr – Jun)

Vision of the Institute

To be a nationally recognized institution of excellence in technical education and produce competent professionals capable of making a valuable contribution to society.

Mission of the Institute

- To promote academic growth by offering state-of-the-art undergraduate and postgraduate programs.
- To undertake collaborative projects which offer opportunities for interaction with academia and industry.
- To develop intellectually capable human potential who are creative, ethical and gifted leaders.

Vision of the Department

To produce globally competent electronics & communication engineering students with knowledge of core as well as inter-discipline domains.

Mission of the Department

- Educating the students in field of electronics and communication engineering to create competent professionals with moral values, social ethics and pursuing higher education.
- Inculcating the understanding technical competence in the fields of electronics and communication engineering and implementation of theoretical concepts in practical multidiscipline scenarios.

Message from the Head of Department

This issue explores the revolutionary convergence of AI and VLSI, where machine intelligence is reshaping chip design. We examine this new paradigm, the opportunities and barriers in intelligent electronic design automation (EDA), and the evolving directions poised to transform the future of semiconductor innovation.

AI in VLSI: Revolutionizing Chip Design with Machine Intelligence

AI is transforming the field of Very Large-Scale Integration (VLSI), moving beyond just accelerating computational tasks to becoming an essential partner in the chip design workflow. The complexity of modern chips, particularly at advanced process nodes like 3nm and below, has reached a point where traditional, manual design methods are no longer efficient. AI, leveraging techniques like machine learning (ML) and reinforcement learning (RL), is now automating and optimizing critical stages of the design process, from high-level synthesis to the final physical layout. This shift is not only accelerating design cycles and reducing time-to-market but also enabling engineers to achieve unprecedented levels of power, performance, and area (PPA) optimization. By handling repetitive and data-intensive tasks, AI frees up engineers to focus on higher-level innovation, pushing the boundaries of what's possible in semiconductor technology.

News Highlights

- Demand for semiconductors up ~29 % by end-2026 driven by growth in generative AI.
- AI tools increasingly used in VLSI design automation: placement, routing, verification, defect analysis.
- Emerging “foundation models” for circuits: models pre-trained (self-supervised) on circuit data then fine-tuned for tasks like quality evaluation, context generation, verification.
- Rise of architectures for AI accelerators (e.g. in-memory computing, near-memory computing) to reduce data movement and improve efficiency.
- Growth of heterogeneous integration and chip-lets / 3D stacking to meet performance & power constraints.
- AI helping sustainability: optimizing power use in chips, improving yield to reduce waste.
- Universities and labs are developing cross-layer neural architecture search and tools using AI agents for digital ASIC optimization.

AI-Driven VLSI: A New Paradigm in Electronics

The integration of AI into VLSI is a fundamental shift in how chips are conceptualized and built. In the design phase, AI-powered Electronic Design Automation (EDA) tools are now capable of analyzing vast solution spaces to find the optimal balance of power, performance, and area (PPA) that would be impossible for human engineers to explore manually. For example, reinforcement learning algorithms can learn from previous design outcomes to predict and correct issues like routing congestion and timing violations before they occur, significantly reducing design iterations. This "shift-left" approach allows for proactive design adjustments, ensuring higher quality and a faster time to tape-out.

In the applied fields, AI in VLSI is a critical enabler for next-generation systems. For AI chips themselves, AI is used to optimize specialized architectures for deep learning workloads. In automotive, AI-designed chips are crucial for real-time sensor fusion and decision-making in autonomous vehicles. For the Internet of Things (IoT), AI helps design ultra-low-power chips that can perform on-device computation, extending battery life and reducing latency. The impact extends to manufacturing as well, where AI-driven predictive maintenance and defect detection systems are improving production yields by analyzing microscopic data from the fabrication process.

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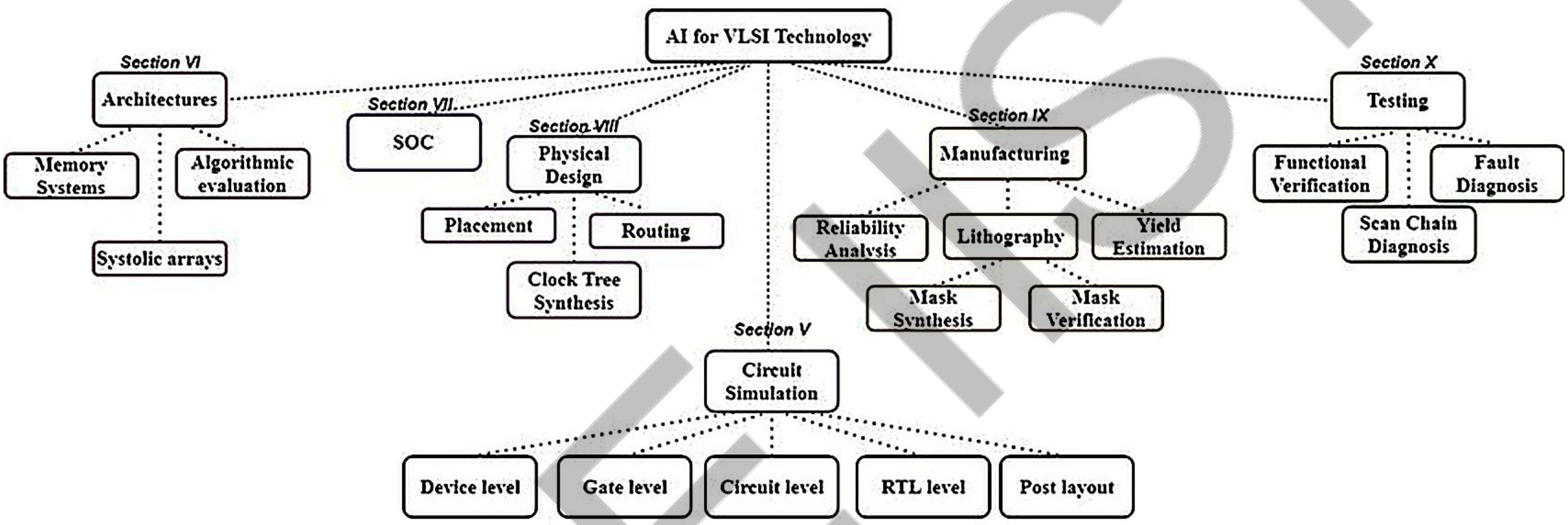
Intelligent VLSI Design: Opportunities and Barriers

The adoption of AI in VLSI presents immense opportunities but is not without its challenges. The primary opportunity lies in overcoming the increasing complexity of designs, which at sub-5nm nodes, has made traditional methods unsustainable. AI-driven tools offer a path to achieve better PPA, shorter design cycles, and higher predictability in timelines. This enables companies to innovate faster and capture leadership in a fiercely competitive market. The integration of AI also opens the door to new architectures, such as chiplets, where AI algorithms optimize how modular components are interconnected for maximum performance.

However, several challenges must be addressed. Data availability and quality remain a major hurdle; training effective AI models requires vast amounts of high-quality, historical design data, which can be difficult to acquire and process. Furthermore, tool integration is an ongoing concern, as companies need to ensure that different AI-powered EDA tools can communicate effectively without creating new bottlenecks. There is also a talent gap, as a new generation of engineers needs to be proficient in both VLSI design principles and AI/ML methodologies. The cost of AI infrastructure and the security of proprietary design data in cloud-based AI systems also present significant barriers.

Despite these challenges, the industry is moving rapidly towards this new paradigm. Companies and academic institutions are collaborating to create standardized workflows and specialized training programs. As AI becomes more deeply embedded, it will fundamentally redefine the role of the VLSI engineer, transforming it from a manual, iterative process to a strategic, AI-augmented one.



AI in VLSI: Evolving Paradigms and Directions

The field of AI in VLSI is rapidly evolving, fueled by a number of transformative trends. One of the most prominent is the rise of generative AI for design synthesis. Traditionally, AI tools focused on optimizing existing layouts and reducing design complexity. Today, generative models are going beyond optimization by autonomously creating entirely new chip architectures and layouts directly from high-level specifications. This shift promises a significant leap in design productivity, innovation speed, and exploration of unconventional architectures, potentially reducing design cycles from years to months. Closely tied to this is the concept of AI-driven hardware for AI, where designers leverage AI to create specialized processors and accelerators that will, in turn, power the next generation of AI workloads—forming a self-reinforcing cycle of progress.

Another crucial trend is the use of AI in semiconductor manufacturing. Machine learning models are increasingly integrated into fabrication processes for real-time defect detection, yield enhancement, and predictive maintenance of expensive equipment. This application not only improves operational efficiency but also minimizes the astronomical costs of advanced-node manufacturing, where even minor process variations can have significant impacts. By harnessing AI at both the design and fabrication levels, the VLSI ecosystem is moving toward a future of faster innovation, greater reliability, and more sustainable semiconductor development.

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"AI is no longer just running on chips—it is now designing and perfecting them"

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Finally, the push for Edge AI is a powerful trend shaping VLSI. As more AI workloads move from the cloud to on-device hardware, there is a need for highly energy-efficient and compact AI accelerators. AI is being used to design these specialized chips, optimizing them for low-power operation and integrating them seamlessly into consumer electronics, IoT devices, and wearables. These trends highlight the symbiotic relationship between AI and VLSI, where each technology's advancement drives the innovation of the other.